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Technical Memorandum No. 23

Effectiveness of Warning Lights as a Function of Flash Rate

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ABERDEEN PROVING GROUND, MARYLAND

Technical Memorandum No. 23

Effectiveness of Warning Lights as a Function of Flash Rate

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A B S T R A C T

This paper investigated the extent to which changes in flash frequency would change the effectiveness of a warning light in eliciting a reaction. Ten subjects were required to judge which flashing light they would turn off first. It was found that the effectiveness of the warning light increased as a direct function of the flash rate, reaching maximal effectiveness at approximately 10 cps. Further increases in frequency produced a decrease in effectiveness. There is some evidence to indicate that effectiveness, apparent fluctuations, and disagreeableness all vary in the same way as a function of flash rate.

EFFECTIVENESS OF WARNING LIGHTS AS A FUNCTION OF FLASH RATE

In many practical situations, warning lights are used to indicate the presence of a malfunction of equipment. Often there are several warning lights on a given display with different lights appearing for different malfunctions. Since some malfunctions are more crucial than others, it is desirable to convey this information to the operator so that these can be corrected first. One obvious solution is to label or code the lights. In addition to this, it would be highly desirable to use some stimulus characteristics of the lights themselves to produce "response demand". The present study is concerned with the effect of different flash rates in eliciting such response demand.

PROCEDURE

Ideally, the subject might be presented with two or more flashing lights and required to do something to turn off one of the lights before the others. This situation would be fairly comparable to that of an operator who must repair the fault associated with one warning light as opposed to a fault associated with another light. Due to current apparatus limitations, however, in the present study the subjects were simply asked "which warning light would you turn off first?"

Ten male volunteer subjects were used singly in sessions of approximately 20 minutes duration. Each subject sat about 2 feet from two Strobotacs* in a moderately illuminated room. The Strobotacs were 12 inches apart and transmitted light to the subject's view through a 3/4 inch diameter aperture. These apertures were covered with a thin velum paper to diffuse the light.

During each stimulus presentation, both Strobotacs flashed simultaneously, each at its own rate. The duration of each flash was constant at approximately 1×10^{-5} seconds. Ten different flash rates from 1 to 60 cps were given in a sequence which was balanced for position effects. Forty-five presentations were given to each subject via the method of paired comparisons. Unlimited time was allowed for a choice and about five seconds elapsed between presentations.

* Manufactured by the General Radio Corporation, Model #631-BL.

RESULTS AND DISCUSSION

The results are presented in Figure 1. The average percent preference for the ten subjects is plotted against the flash frequency of the warning light. Up to ten cps, an increase of flash rate results in an increase in preference. At 10 cps, maximum preference is shown. Further increases in flash rate produce decreases in preference. Since the preference figures for 50 and 60 cps are identical, it would seem that further increases in frequency would produce little or no effect. At the lower flash rates, however, it is quite possible that decreases in frequency below 1 cps would further decrease the preferability of the signals.

The data for one subject differed appreciably from the averaged data seen in Figure 1. This atypical subject consistently preferred the lower flash rates, and therefore, showed a maximum preference at the lowest rates used. The data for the other nine subjects closely resemble each other as to the form of the curve, but there is some variation as to when the curve reaches a maximum (6-15 cps).

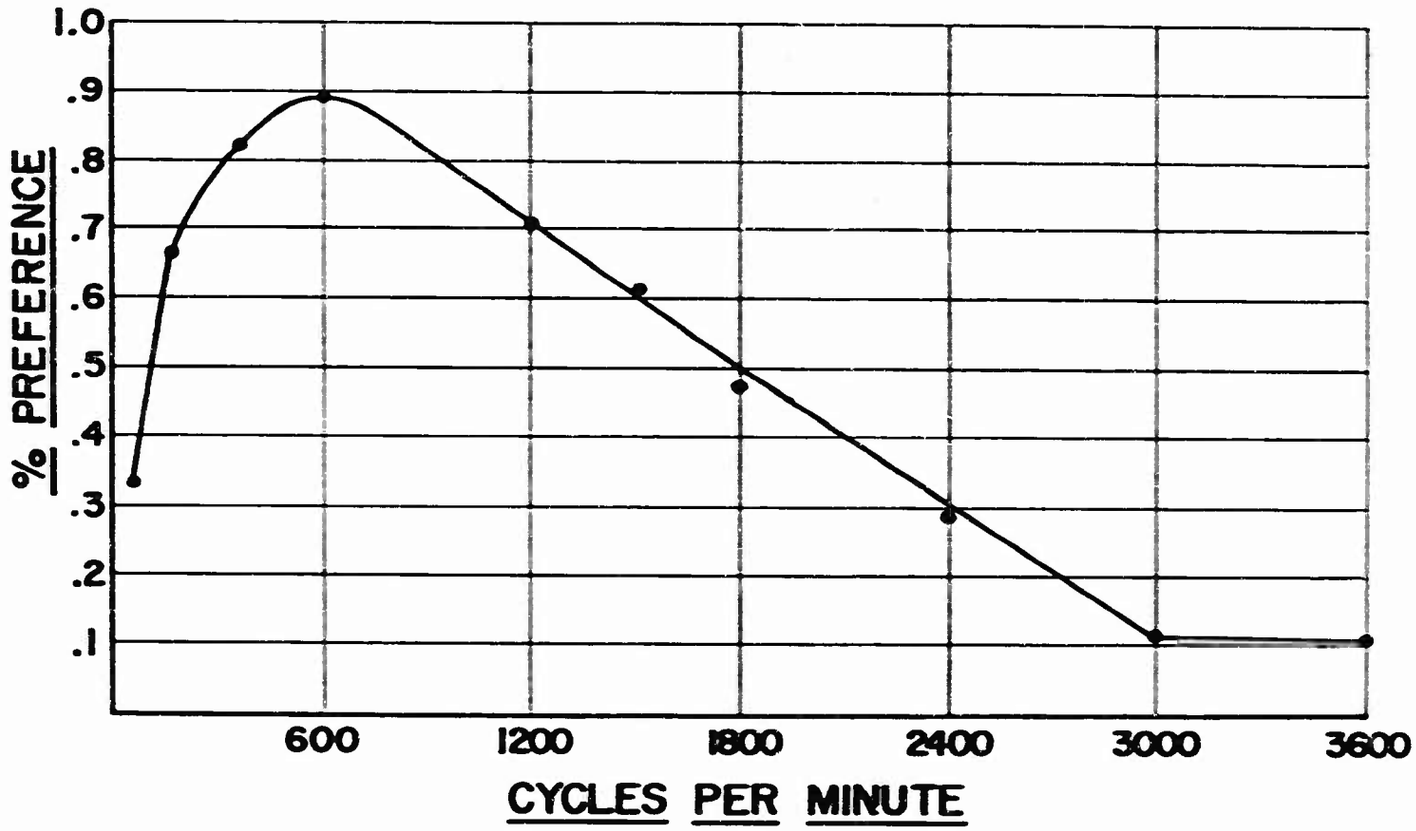
The subjective appearance of the lights seems to be related to their measured effectiveness. At the lower rates, the lights appear simply as an alternation of light and dark in the visual field. This alternation has been called "flackerlicht" (2). With further increases in flash rate above 5 cps, the visual field appears as alternations of light and lighter rather than light and dark. This latter type of alternation has been called "flimmerlicht" (2). It is in this region of transition, 5-12 cps, that maximum effectiveness occurs. Additional increases in rate reduces apparent fluctuations until apparent fusion is reached at approximately 50 cps. It appears then that effectiveness of the warning lights is associated with the frequency with which the lights appear to fluctuate.

Strughold (2) has investigated the subjective reactions to intermittent light stimulation using a three point scale: tolerable, disagreeable and very disagreeable. His results indicate that a frequency of 1 cps was tolerable while 2 cps was unpleasant. Frequencies of 3 to 5 cps fell within the very unpleasant range. The intensity of the flickering light was about 200 lux measured at the eye. In the present study where the intensity of light was approximately 1 ft. candle, measured at the source, only two subjects reported the flickering lights to be disagreeable.

Recently Gerathewohl (1) has reported that reaction time decreases with increases in frequency for fairly slow flash rates up to 3 cps. No relationship between reaction time and higher flash rates were reported. The findings of Strughold (2) and the results of the present study appear to be consistent with the work of Gerathewohl.

Flickering light has also been used clinically to produce photo-shock, i.e., to produce abnormal rhythms in the electroencephalogram as a diagnostic aid for epileptics (3). In addition to photo-shock, intermittent stimulation with a high intensity light has been found to produce nausea, dizziness, fainting, etc. Whether these results are a function of either frequency or intensity, or particular combinations of frequency and intensity would be difficult to specify at the present.

At any rate it would appear that the results of the present study might be interpreted in terms of the disagreeable nature of intermittant stimulation at particular frequencies. However, a number of related variables must be



PREFERENCE OF INTERMITTENT LIGHT STIMULATION AS A FUNCTION OF FLASH RATE

Fig. 1

investigated before any generalized conclusions can be made. These variables include intensity, color, on-off durations, etc. These variables will be investigated in future studies.

SUMMARY AND CONCLUSIONS

This study investigated the extent to which changes in flash frequency would change the effectiveness of a warning light in eliciting a reaction. Ten subjects were required to judge which flashing light they would turn off first. It was found that the effectiveness of the warning light increased as a direct function of the flash rate, reaching maximal effectiveness at approximately 10 cps. Further increases in frequency produced a decrease in effectiveness. There is some evidence to indicate that effectiveness, apparent fluctuations, and disagreeableness all vary in the same way as a function of flash rate.

Further study of such variables as contrast ratio, intensity, color, etc., should make it possible to determine what kind of warning lights should be used under a given set of conditions.

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